Underground Storage Tank Remediation Project at Department of Defense Housing Facility, Novato, CA (continued)

Jim Gibbs

Battelle
. . . Putting Technology To Work

Technology Considerations

- Objectives
  - Remove adequate mass to make site low risk and allow implementation of remediation by natural attenuation
  - Achieve above objective within timeframe of site transfer requirements
  - Minimize cost
  - Minimize worker health risk

Low Risk Site Criteria

- Leak stopped/Free product removed
- Adequate site characterization
- Dissolved hydrocarbon plume is not migrating
- No receptors impacted (wells, surface water)
- No significant human health risk
- No significant ecological risk

Risk-Based Approach

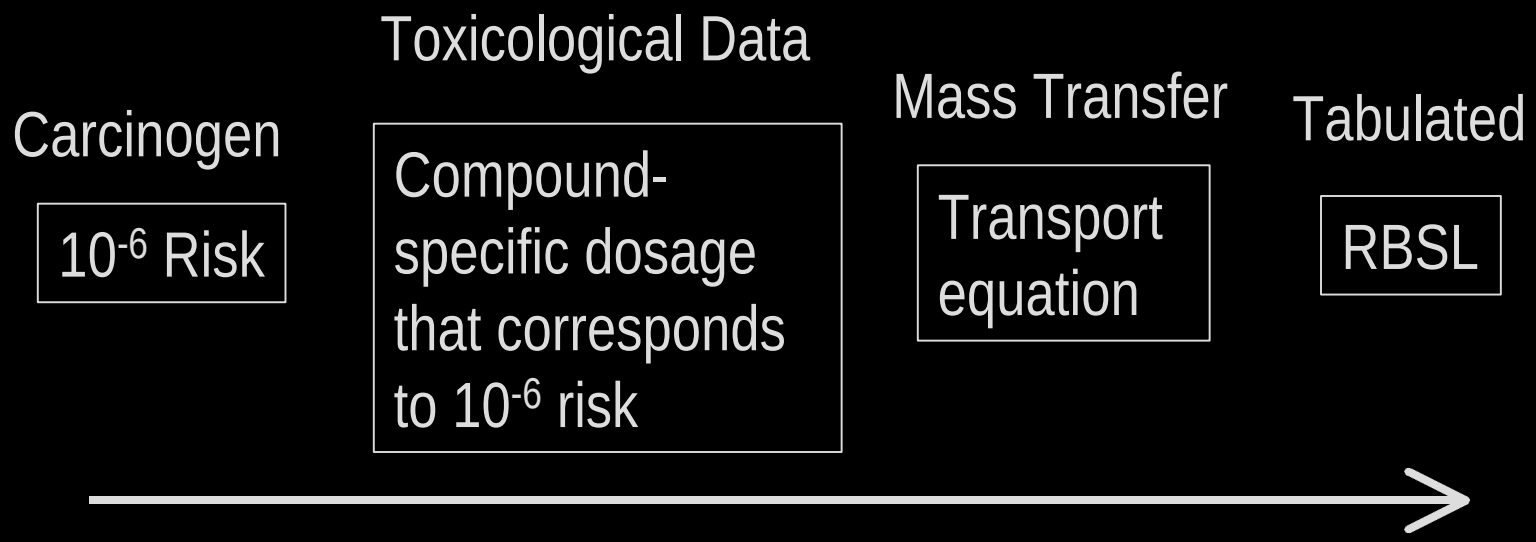
- Evaluate risk to human health using procedures based on ASTM E 1739-95 Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites (RBCA)

RBCA - Tiered Risk Evaluation

- Tier 1
  - Conservative assumptions applied to all release sites
  - No site-specific information used
  - Transport equations used to back-calculate Risk-Based Screening Levels (RBSLs) from maximum permissible risk and dosage
  - Site concentrations compared to RBSLs

RBCA Tier 1 Calculation - Example

Performed on each compound for each applicable exposure pathway:



Example Equation for Pathway: Subsurface Soil to Outdoor Air Inhalation

Example Equation for Pathway: Subsurface Soil to Outdoor Air Inhalation

Health and Ecological Risk Factors - Pathways and Receptors

- Potential Pathways
  - Human Health Risk
    - Volatilization from soil to air
    - Volatilization from groundwater to air
    - Dermal contact
  - Ecological Risk
    - Pacheco Creek
    - Storm water runoff system

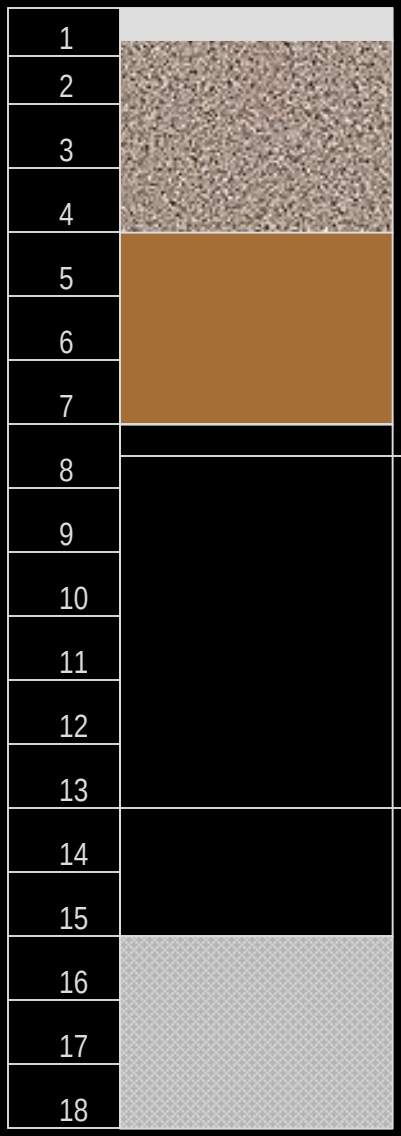
Health and Ecological Risk Factors - Pathways and Receptors

- Potential Receptors
  - Human
    - Workers
    - Building occupants
    - Agricultural workers? (possible irrigation water use)
  - Ecological (complete pathway unlikely)
    - Sensitive biota
    - San Pablo Bay

Geological Description

- Likely deposit-filled stream bed
- Alluvial deposits
- Surficial fill material
- Interbedded gravels, sands, silts, and clays
- Aquitard encountered at 15 ft
- Bedrock to the east and west

Typical Soil Lithology



Asphalt pavement

Loose dry sand; reddish-brown changing to gray or green-gray around 2 ft below ground surface (bgs); usually no odor

Sandy clay; slightly moist; dark brown, often with an organic odor, but not necessarily a petroleum odor

High water table

Clayey-sand, often with narrow layers of concentrated gravels or clays; gray or gray-brown. Fuel odor typically strongest proximal to water table or in permeable saturated layers

Low water table

Aquitard

Semi-consolidated sand and clasts, sometimes very dense clayey-sand, dry to very slightly moist. No odor. Typically mottled gray and iron oxide color

Hydrogeological Description

- Groundwater encountered at 7.5 to 13 ft below ground surface (bgs)
- Smear zone within that fluctuation
- Groundwater gradient 0.014 ft/ft
- Groundwater velocity ~0.2 ft/d
- Hydraulic conductivity ~4 ft/d
- Sand content in permeable layer 70 to 90%

Aquifer and Soil Evaluation

- Aquifer
  - Groundwater sampling
    - concentrations of benzene, toluene, ethylbenzene, and xylenes (BTEX); and methyl *tert*-butyl ether (MTBE)
    - total dissolved solids (TDS)
    - natural attenuation parameters
      - Fe
      - SO4
      - NO3
      - CH4
      - TMB
      - TeMB

Aquifer and Soil Evaluation

- Aquifer (continued)
  - Pump tests
    - sustainable yield
    - hydraulic conductivity
  - Slug tests
  - Groundwater gradient

Aquifer Evaluation to Determine Beneficial Use

- US Army demonstrated non-beneficial use aquifer
  - Total dissolved solids (TDS) > 3,000 mg/L
  - Sustained production < 200 gallons per day
- DODHF Novato
  - Groundwater sampling
  - Slug tests
  - Pump test

Aquifer and Soil Evaluation

- Soil
  - Soil sampling
    - concentrations of BTEX and MTBE
    - grain size distribution
    - bulk density
  - Continuous coring for lithological data
  - Cone Penetrometer study

Technology Considerations

- Remediation needs
  - Remove free product (if present)
  - Reduce concentrations in groundwater
  - Reduce concentrations in soil

Reduce Concentrations in Groundwater

- Reduces risk
- Reduces plume migration potential
  - Reduces concentration gradient in groundwater
  - Monitored by quarterly groundwater sampling

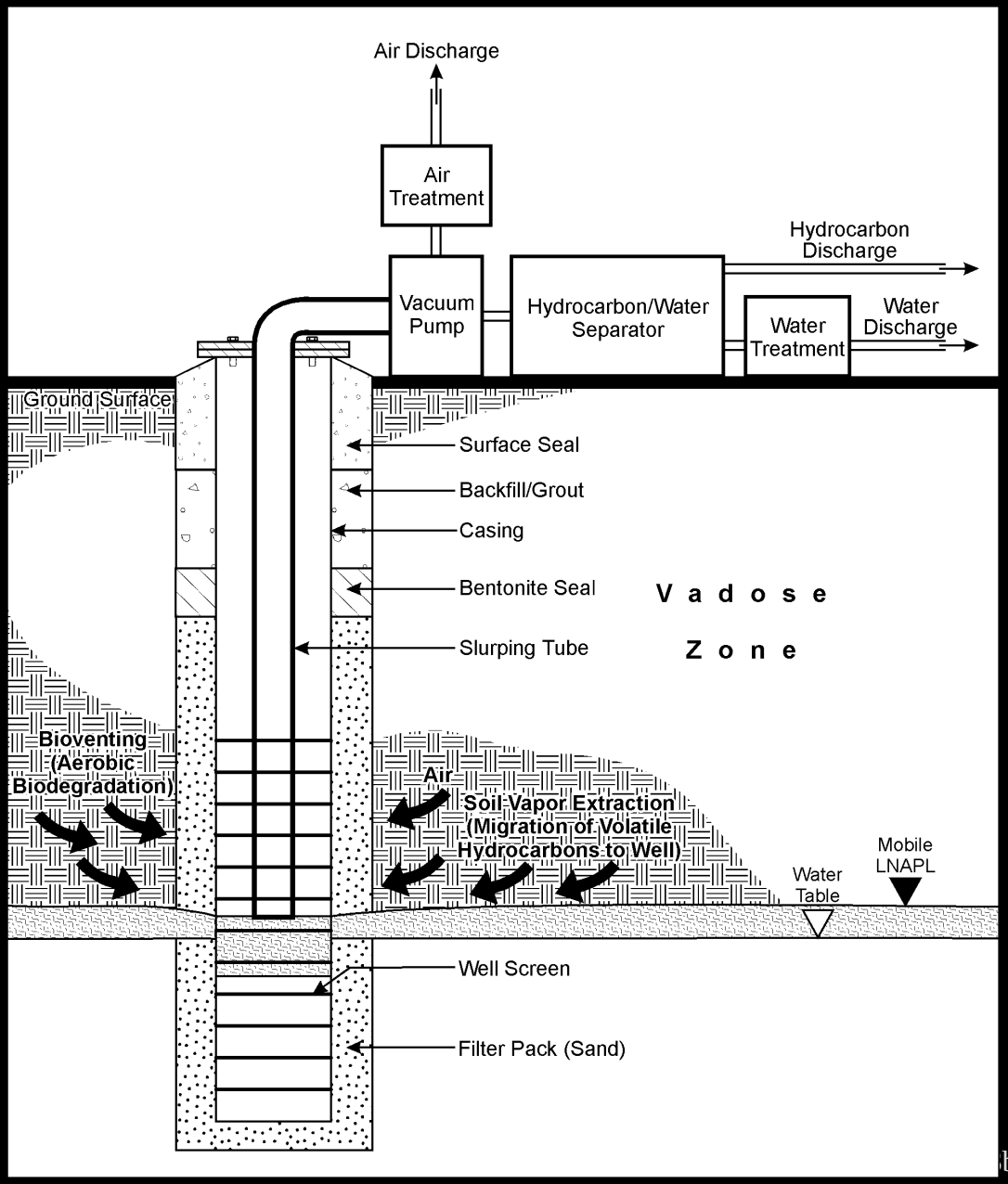
Free Product Removal (if present)

- Bioslurping
  - Demonstrated as best available technology for free product removal
  - Vacuum enhanced multi-fluid extraction
  - Removes recoverable free product
  - Enhances biodegradation in vadose zone

Bioslurping

- Vacuum pipe inserted into well to withdraw free-floating petroleum and soil vapor
- Enhances lateral migration of fuel into wells for removal
- Enhances biodegradation in soil (by aerating soil)
- Results in fuel, water, and vapor streams

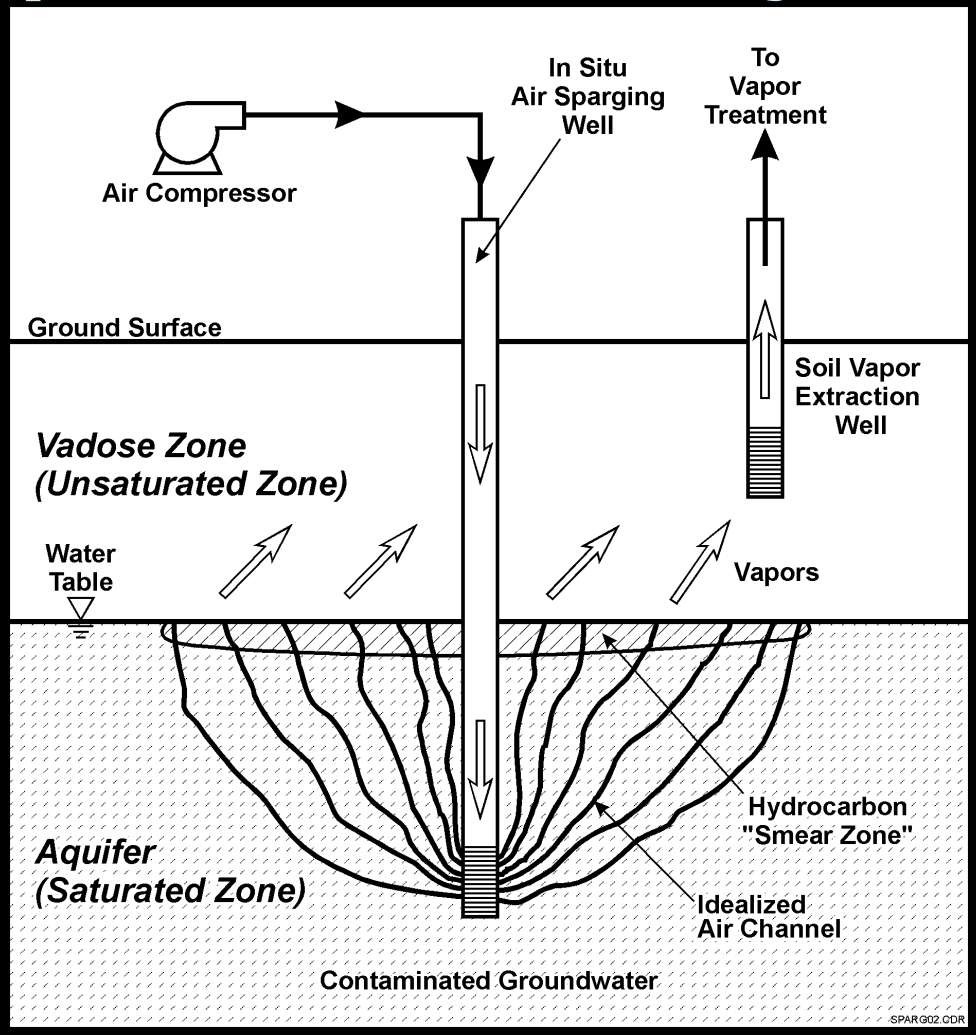
Bioslurper System



In Situ Air Sparging (IAS)

- Injection of air under pressure directly into aquifer
- Strips hydrocarbons from groundwater
- Enhances biodegradation in aquifer and in unsaturated soils
- Frequently accompanied by soil vapor extraction (SVE)

In Situ Air Sparging/ Soil-Vapor Extraction System



Soil Vapor Extraction (SVE)

- Withdraws vapor from among soil particles
- Enhances volatilization of hydrocarbons from sorbed soil sites
- Conducts vapor to surface for treatment
- Protects against uncontrolled vapor release and migration

MTBE Plume Characterization

- GeoProbe sampling performed 1997
- GeoProbe sampling performed 1998
- Cone Penetrometer sampling performed 1998
- 5 monitoring wells installed 1998
- 4 temporary piezometers installed 1998
- further investigations under discussion

MTBE Approach

- Evaluate IAS/SVE system MTBE removal effectiveness
  - stripping likely to be effective initially due to high MTBE concentrations
- Make recommendations for improvement and optimization
  - continue operation
  - expand system
  - select different technology

Progress Review

- Previous investigations reviewed
- Preliminary investigations completed
  - technology specific
  - Tier 1 risk assessment
  - special site requirements
- Interim remedial action system installed
- baseline sampling completed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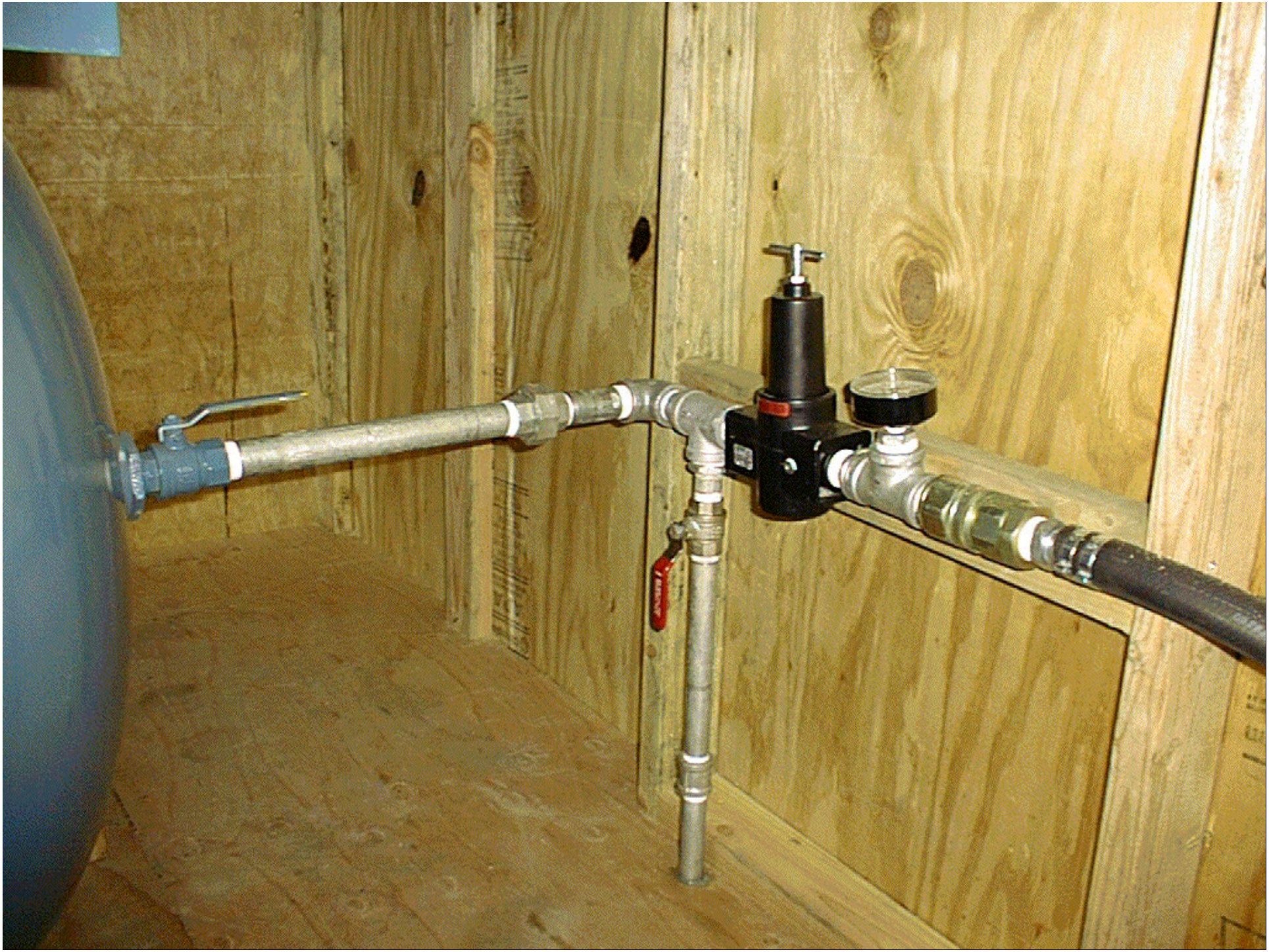
QRD-25


TOYOTA



Exit Strategy

- Demonstrate that site is low risk
- Determine if Remediation by Natural Attenuation (RNA) is likely to be effective alternative
- Implement RNA
  - RNA includes long-term groundwater monitoring
  - Establish concentration trends

System Expansion

- Implemented if technology effective, but not achieving adequate removal due to scale of systems
- Oversized equipment to enable expansion (if necessary)

Remedial Action Objectives

- Removal of adequate mass to result in
  - low risk site
  - plume collapse
  - concentrations that can be remediated by RNA with acceptable impact

Long Term Monitoring

- Implemented in conjunction with remediation by natural attenuation
  - BTEX and MTBE concentrations
  - natural attenuation parameters

Site Closure

- Expected to be achieved when trends from monitoring and RNA adequately demonstrate that plume is shrinking at an acceptable rate